LOS/PCN/SCN.1/WP.15
5 August 1992

ORIGINAL: ENGLISH

PREPARATORY COMMISSION FOR THE INTERNATIONAL
SEABED AUTHORITY AND FOR THE INTERNATIONAL
TRIBUNAL FOR THE LAW OF THE SEA
Special Commission 1
New York, 10-21 August 1992

PROJECTION OF FUTURE DEMAND, SUPPLY AND PRICE OF THE METALS CONTAINED IN POLYMETALLIC NODULES

Background note by the Secretariat

INTRODUCTION

1. In undertaking studies on the problems which would be encountered by developing land-based producer States likely to be most seriously affected by the production of seabed minerals, Special Commission 1 felt the need to address the issue of the future market situation with regard to copper, nickel, cobalt and manganese, the metals deemed likeliest to be produced from polymetallic nodules when they would be mined from the seabed in the future. Consequently, the Commission requested the Secretariat to prepare a background paper on the issue of projection of future demand, supply and price of these four metals. The present document has been prepared in response to that request.

2. The nature of the interest of Special Commission 1, and for that matter, of other organs of the Preparatory Commission, in the projection of future market situation evolved in a significant manner over time. As the realities of the metal markets during the late 1970s and the 1980s and of the technology development with regard to seabed mining pointed to the fact that seabed mining might not occur before the year 2000 and that the earliest possible commencement of seabed mining might be in the first, or even the second decade of the next century, the interest of Special Commission 1 concentrated less on the projections themselves or on carrying out projection exercises, and more on the understanding of what is involved in projection exercises and on monitoring trends and developments in the metal markets. The latter is essentially for the purpose of keeping abreast of the metal market situation

and of positioning the International Seabed Authority for taking necessary decisions or actions at the appropriate time when seabed mining becomes imminent.

3. This evolution of approach is also evident in the work of the Chairman's Advisory Group on Assumptions established in 1986 with a mandate entrusted to it by Special Commission 2 to monitor the economic conditions for seabed mining so that it could advise the Special Commission on when it might be possible to revise the current model of the Preparatory Commission for seabed mining contained in the Australian study LOS/PCN/SCN.2/WP.10 and Add.1. The Group reviewed periodically the short-, medium- and long-term forecasts for the production, consumption and prices of the four metals. At the end of the last session, it reported, "...The Group feels that it is necessary to emphasize that the work of the Group needs continuity. In this connection the Group suggests that during the period before entry into force of the Convention, its successor should concentrate, inter alia, on periodic analysis of world markets and metal prices, their trends and forecasts; collection of information on and evaluation of technological developments, assessment of the state of knowledge of deep-sea environments and possible impacts of seabed mining activities." (LOS/PCN/L.100, para. 29).

4. In preparing the present document, the Secretariat drew upon the work of the Group, and utilized the combined base of data, information, research and analysis on projection of demand, supply and price of the four metals concerned, which has been developed in the Secretariat to service Special Commissions 1 and 2 and other organs of the Preparatory Commission. The issue of projection was also discussed in Special Commission 1 in considerable length. Summaries of such discussion can be found in the statements of the Chairman of the Special Commission to the Plenary (see, in particular, LOS/PCN/L.58, paras. 20-23, and LOS/PCN/L.63, paras. 4-8). The present paper builds upon such discussion as well. Pursuant to the above considerations, the present paper discusses the essentials of the projection exercises, highlights what is to be monitored in relation to projections, and how best the monitoring can be achieved. Long-term projections of demand/supply/price of copper, nickel, cobalt and manganese, that are available currently are also addressed briefly with a view to presenting a broad overview and giving an idea about the various methodologies used in projection exercises.

I. ESSENTIALS OF PROJECTION EXERCISE

5. The issue of projection of future demand, supply or price of metals was addressed even during the Third United Nations Conference on the Law of the Sea. The often-quoted statement is found in the Progress Report of the Sub-Group of Technical Experts of Negotiating Group 1 of the Third United Nations Conference on the Law of the Sea: "The experts agreed that, by definition, the future is unknown and unknowable, but it was recognized that some statements about future consumption or production ... are more likely to be true than others". 1/ However, although the latter part of the quotation rules out extremes, the range of likelihood can be quite wide indeed.

6. The basic process for projecting future demand, supply and price of metals is (a) to examine the past for patterns and relationships, and (b) to develop methodologies that incorporate the lessons of the past with the situation in the future. It can be easily seen why and how a wide degree of variability can arise in the outcomes of projection exercises. First, the past patterns and relationships in the real world are many; projection exercises can vary depending on which patterns and relationships are focused on and to what extent. Secondly, the nature and degree of application of the lessons of the past to the future depends on the judgement of the projection expert, and such judgement can be different for different experts. Thirdly, and here one projection exercise becomes part of another projection exercise and thus, the extent of variability can multiply, the ideas about the future situation where the lessons of the past would be applied can be very different indeed from one projection expert to another. Fourthly, methodologies can vary among projection experts.

7. The issue of variability in the outcomes of projection exercises become much more pronounced when certain trends and developments in the past and the present point to considerable uncertainties with regard to the future, in contrast to the relative stability in the past and the expectations of relative stability in the future. There are reasons, to be discussed later, to believe that such uncertainties characterize the current metal market situation.

8. In addition to variability, there can be consistent underlying biases upward or downward in the projection exercises depending on the circumstances at the time of projection. In May 1986, the United States Bureau of Mines (USBM) and the Henry Krumb School of Mines of Columbia University held a conference on changes in the global metals industry. Reporting on the conference, David A. Gulley of the Henry Krumb School of Mines, inter alia, adds a cautionary note: "Retrospective studies of forecasting document the (perhaps obvious) point that the degree of optimism in the forecast matches the degree of optimism during the period the forecast was made". 2/ It goes without saying that the statement is equally valid regarding the degree of pessimism.

Factors on which projections depend

9. The future demand, supply and price of a metal can be projected separately and independently, but usually a more consistent approach is to project future demand, supply and price together within the framework of an overall equilibrium model. In the latter approach, at the equilibrium, supply equals demand, and price takes up the equilibrating role.

10. There are two basic ways future supply/demand/price of a metal are projected - one is to extrapolate the past time-trend to the future, and the other is to estimate future supply/demand/price as resulting from the influences of appropriate determining factors.

11. In extrapolating the time-trend, a period of recent past is chosen, the underlying movement over time of supply/demand/price (growth/decline/constancy) during that period is estimated and, assuming that whatever underlying factors were behind the past experience will also repeat themselves in the future, the estimated rate of movement is applied to future supply/demand/price. The major problem with this approach is that the underlying factors in the future may be quite different from those in the past. Another important problem is that past experience varies in the different past time periods and thus, depending on the time period chosen, the future extrapolation will also be different.

12. The time-trend approach to projection has some advantages, however. It is a simple approach, involves considerably less effort and cost compared to the other approach, and avoids the problems of dealing with determining factors. These were the main reasons that this approach has been incorporated in article 151 of the United Nations Convention on the Law of the Sea, when the issue of future nickel consumption has been addressed. (Consumption is the main component of metal demand, demand being equal to consumption - changes in consumers' stock.)

13. The approach involving determining factors requires a number of basic steps. First, important factors that have influence on metal demand/supply/price are identified. Secondly, the nature and extent of influence these factors had on metal demand/supply/price in the past are measured. Thirdly, future values of the determining factors are obtained. Finally, on the assumption that the determining factors would operate in the future as they did in the past, future demand/supply/price is estimated.

14. It can be easily seen that the estimates/projections can vary according to differences in the determining factors selected, variations in the measured natures and extents of their influences, differences in the future values of the determining factors, and the degree of future stability in the structure of influence of the determining factors. In addition, determining factors can be different for short-, medium- or long-term projections.

Factors influencing future demand

15. On the metal demand side, several determining factors can be identified. The four metals, copper, nickel, cobalt and manganese, are used as inputs in such industries as chemical, electrical, electronics, energy, machinery, steel and transportation industries. Thus, the demand for these metals is dependent on the demand for the end-products. One approach, sometimes known as the "bottom-up" approach, recognizes the input requirements of each of the end-use industries separately. This approach requires considerable effort and data. An alternative approach, sometimes known as the "top-down" approach, is to view the demand for metals to be dependent on overall industrial production. As income levels rise, consumption of metals rises too. Thus, gross national product (GNP) or per capita GNP can be thought of as a determining factor. Finally, the price of the metals and price of their substitutes have an influence on metal demand. Other things remaining the same, it is expected

that a higher price of the metals will lead to a lower demand, and a lower price of the substitutes will encourage demand for the substitutes at the expense of the metals in question.

16. Whatever the determining factors selected to estimate demand for metals (levels of production in end-use industries, overall industrial production, GNP, substitutes and their prices), future values of these factors have to be obtained. Usually, these values are obtained by extrapolating the time-trend of past values, or by making some assumptions, directly or indirectly, regarding the behaviour of these factors in the future.

17. Finally, judgement has to be made regarding the nature and extent of influence of the selected determining factors in the future as in the past.

18. Demand for metals on a global scale is usually estimated by dividing the world into country groups. Such disaggregation is particularly important since the behavioural responses of the various country groups can be expected to differ, and since technologies and tastes can also differ.

19. Having discussed the determining factors and the structure of their relationships with metal demand, which by themselves can be the source of considerable variability among various projections of future metal demand, certain areas of uncertainties which appear to be uniquely characteristic of the current situation with respect to the four metals concerned, especially copper and nickel, need to be pointed out. These uncertainties add significantly to the difficulties of projecting future demand at this time.

20. These uncertainties pertain to: (a) the structural relationship of the metals in the production of end-use products; (b) the structural relationship of the end-use products with general economic condition; and (c) the structure of the general economic condition in the global economy itself.

21. There is a widespread perception that at present structural changes are occurring in all the above three avenues, in which case projection of future demand for metals based on the soon-to-be-defunct structural relationships carries very little meaning; or, at the least, fundamental changes are occurring which may or may not result in structural changes, in which case before carrying out any projection exercise, it behoves that how these fundamental changes culminate be monitored. "A profound difference looms between demand responding abnormally to the usual market forces, and responding normally but to abnormal market conditions." 3/ The former involves a structural change, the latter a transient phenomenon in the unchanged structure. The current situation happens to combine both phenomena, and it is extremely difficult to gauge the relative importance of the two for the future. The worst case scenario would be to assume that structural changes have already occurred, and to project future demand on the basis of that changed structure.

22. As to the level of metal input requirements in end-use products, there is evidence that substitution is occurring by other metals or materials for the four metals in question in some end-uses (e.g. replacement of copper wire by fibre optics in telecommunications), and also that certain technologies have been introduced for certain products, which use less of the metals in question as input per unit of output (e.g. stainless steels with lower nickel content). However, new uses of the metals in question have also occurred in the recent period. In any case, it is not conclusive whether the overall metal composition of products has changed significantly and irreversibly as a result of metal-saving substitutions and technology innovations.

23. With regard to the product composition of income, there is evidence that in developed economies there is a shift in favour of less metal-intensive goods, partly because of sectoral shifts from agriculture and manufacturing towards services, and also partly because of intersectoral shifts within the manufacturing sector towards high-technology products. But it is not quite clear whether the product composition of income viewed globally has changed structurally, or what the relative impacts of declining share but growing absolute levels of metal-intensive goods, are.

24. As to the structure of the global economy, considerable uncertainties exist regarding: (a) the long-term growth rates of developed economies; (b) the length and the nature of outcomes of the transition of former centrally planned economies to market economies; and (c) the long-term growth rates of developing economies, especially the larger and relatively more industrialized ones, such as Ghana and Nigeria in Africa, China, India, Indonesia, Malaysia, the Philippines and Thailand in Asia, and Brazil and Mexico in Latin America. A related uncertainty is with regard to use of metal per unit of GNP as income increases in former centrally planned economies and developing economies. While there is evidence that as income rises, metal use per unit of GNP rises up to a certain limit, there is also some evidence that these countries as they develop further are "leap-frogging" the old metal-intensive products and technologies which the industrialized countries used in their earlier stages of development, and are adopting newer, more metal-saving products and technologies.

25. It can be expected that in the near-term future these uncertainties would play themselves out and clearer pictures and directions would emerge. In this perspective, it appears most logical and fruitful for the Authority during its early period of functioning, to monitor the outcomes of these uncertain and unpredictable phenomena.

Factors influencing future supply

26. A picture of the future supply situation for copper, nickel, cobalt and manganese can be obtained from three types of information: plans for expansion of the existing mines and plans for development of new mines, estimates of worldwide reserves of these minerals, and estimates of worldwide resources of the minerals. The worldwide resources of a mineral consist of all deposits, whether discovered or not, that may be exploited now or in the

foreseeable future. The resources of the mineral that are both "identified" and "economic" comprise the reserves. The estimates of reserves and resources can vary according to the judgement made by the estimator regarding the geological and economic characters of the deposits. It should be kept in mind that the reserve and resource estimates are not static. Reserves are increased as new technology reduces the costs of production or when metal prices rise faster than costs of production in a stable fashion. Again, reserves are also increased as exploration makes it possible to classify previously undiscovered deposits to identified deposits.

27. Expansion and new mine development requires about five or six years. So, for the near future, new supplies will be coming from the mines for which construction is already in progress. There is public information available about these, and supply of metals in the near future can be fairly accurately predicted.

28. In the medium-term future, the most likely areas where mines will be developed are the areas that have reported reserves. The exploration for new deposits is a long process, often taking 10 or more years. Thus, areas with known reserves are the ones most likely to be exploited. Reserve estimates, therefore, can give us an idea about the future supply situation in the medium term.

29. In the distant future, the estimates of reserves should be supplemented by the rest of the resources to indicate possible areas of mineral development. Thus, in order to obtain an idea of the long-run supply situation, worldwide resource estimates should be examined.

Factors influencing future price

30. Price forecasts are usually arrived at through an exercise involving the balance of future demand and supply and/or assuming a process for price formation. In order to obtain estimates of future prices from a demand/supply exercise, it is necessary to postulate a relationship between the reserves and resources and price, i.e., to indicate at what price those reserves and resources will be converted to supply in the market. Price forecasts, thus, vary according to the estimates about costs of production from various deposits and the assumptions on price formation.

II. CURRENTLY AVAILABLE PROJECTIONS AND THEIR METHODOLOGIES

31. During the rapid expansion of the world economy after the Second World War, there was uncertainty and concern about the capability of the minerals industry to supply raw materials at the rates needed to maintain industrial expansion. During the 1970s, experience with the Organization of Petroleum Exporting Countries caused a shift in attention from resource adequacy to supply availability but no reduction in emphasis on the importance of the supply of raw materials. These concerns over the adequacy and availability of supplies of raw materials led Governments and industries to commission

numerous studies of the markets for minerals and metals. Some studies focused on the distribution of resources and processing capacity, some on the material requirements of the industrial economies, and some attempted to link supply and demand in complex models designed to project the production, consumption and price of metals decades into the future.

32. The decade of the 1980s began with a strong emphasis in industrialized countries about the uncertainty of the adequacy and availability of minerals and metals. Within several years, however, these concerns faded away. As concern over mineral availability declined, so did support for the analysis and projection of metals markets. To a degree this reflected dissatisfaction with the results of predictive models, but more importantly, it reflected the experience of the past decade that in spite of concerns about the global adequacy and availability of supplies, demand appeared to be more than adequately met. Another important factor was that prospecting and exploration for minerals that began under the expectation of continuation of the high rate of growth of minerals consumption of the 1950s and 1960s identified resources far in excess of the needs resulting from the significantly reduced rate of growth of mineral consumption experienced in the late 1970s and throughout the 1980s.

33. Still, the evaluation of policies for developing and managing mineral resources in the future requires the evaluation of the markets for those minerals. While fully integrated predictive models that attempt to project demand, supply and prices for metals and minerals have lost their popularity, research has continued in the study of the future mineral situation, especially mineral demand, and the knowledge of this research can be of interest to the Special Commission, although in very rare cases the projections go beyond the year 2000.

34. A variety of approaches using sophisticated models and projection methods have been used to make projections of the future demand for the four metals concerned. While all of the prominent modelling methodologies depend upon the analysis of past behaviour, they utilize different mechanisms for applying the lessons of the past to the projection of market behaviour in the future, as illustrated by the description of methodologies below. The following examples have been selected in order to provide an overview of the significant methodologies; also, each of these examples address more than one metal in question.

United States Bureau of Mines (USBM): Combination of time-trend and econometric methods

35. For many years the United States Bureau of Mines (USBM) has published long-term forecasts of metal and mineral consumption in its publications Mineral Facts and Problems and Mineral Commodity Profiles. 4/ At present, the USBM has suspended publishing these forecasts while it reviews its forecasting methodologies. In the past, the USBM forecasts have been produced on a metal-by-metal basis by dividing the consumption of each metal into its principal uses, developing equations to correlate trends to appropriate

economic indicators, obtaining projections of those indicators into the future by sources outside the USBM, applying the judgement of the metal analysts regarding the effects of technology change and metal substitution, and adding the consumption of the individual uses to arrive at the projected consumption for specific years in the future. High and low projections were also produced to bracket the range of projections resulting from variations in the judgements regarding technology change and substitution.

36. The strengths of the USBM projections were in the USBM's database of domestic and international metal consumption by end-use and the experience and professional skill of the individual metal analysts. The weaknesses were the assumption, inherent in the trend line extrapolation of consumption, that there would not be significant changes in general trends of the economy, and the independence of the projections from one another so that judgements related to technology change or substitution were not applied uniformly among commodities.

Resources for the Future (RFF): Comprehensive appraisal, including econometric modelling

37. Resources for the Future (RFF) is a non-profit research institution that was formed in response to the recommendation of the United States President's Commission on Materials in the early 1980s that an independent centre for the analysis of resource issues be established to serve the public interest. Since then, RFF has prepared numerous forecasts of the mineral requirements of the United States and the world. The modelling techniques used in these forecasting exercises were selected in recognition of the highly skilled and experienced minerals experts available to RFF, so that the forecasts would incorporate the expert judgement and experience of the forecasters into the details of the models.

38. Landsberg, Fischman and Fisher. One of the early efforts to assess systematically the outlook for minerals consumption was produced by RFF for the 1963 publication Resources in America's Future. 5/ The study focused on domestic mineral and metal needs rather than global requirements, but it served as a model for later forecasts, both domestic and global.

39. The forecasts prepared as part of this project were based on a range of assumptions about the economic conditions in the future and about the role of materials in the economy of the future. The forecasts were made for 1980 and 2000 in three scenarios: low, medium and high growth. The forecasts for copper consumption in 1980 and 2000 are shown in table 1, along with the actual 1980 value of copper consumption. In comparison with the actual growth of metal consumption, even the low growth forecast substantially overestimated the United States domestic consumption of copper in 1980. This was due, in part, to a reduction in the overall growth of the economy, but it also reflected changing patterns of copper use due to changes in manufacturing processes and in the consumption of products containing copper; this also exemplifies the difficulties of making projections.

Table 1

United States consumption of copper

(Projected by Resources for the Future in 1963)

(million tons)

	1980	2000
Low	2.2	2.8
Medium	3.6	6.8
High	5.2	14.0
Actual	1.9	

Source: Projections from Landsberg, et al., op. cit., actual consumption from United States Bureau of Mines.

40. The forecasting technique used in Resources in America's Future was described as a "comprehensive appraisal". This appraisal used a number of techniques to arrive at its forecasts, but the most important factor was the experience and knowledge of the group of researchers preparing the forecast. The result was a forecast that was highly integrated among its components (including substitution among the various materials). The strength of the model was in the ability of the modelling team to integrate data from many sources so that it fit into a common analytic framework in spite of differences in quantity and quality of information, and to assess the implications of qualitative trends in materials production and consumption for the quantitative projections of metal and mineral consumption.

41. Fischman. In 1980, RFF published the report World Minerals Trends and U.S. Supply Problems, 6/ based on a study directed by Leonard Fischman. Consumption forecasts were based on demographic and macroeconomic projections, with considerable expert judgement about the changing relationship of materials consumption to population and GDP. As with earlier RFF studies, the 1980 forecasts supplemented the use of statistical analysis and mathematical calculation with the expert judgement of the forecasters.

Leontief: Input-output modelling

42. Analysts of the world economy gained a powerful tool with the development of the input-output model, a technique pioneered by Wassily Leontief while formulating models of the United States and world economies. Input-output modelling begins with a projection of future production of goods and services, then working backwards through the production processes to identify the inputs

of material, labour and capital required to fulfil the production projections. The matrix of input-output relationships can be varied over time to reflect changes in technology (i.e. metal composition of products) and substitution between materials. A team led by Leontief adapted national and global input-output models to project future metal requirements up to the year 2030. 7/ These projections, which were published in 1983, included three of the four metals that may be produced from polymetallic nodules: copper, nickel and manganese. The projections are reported in table 2.

Table 2

Projected world consumption of copper, nickel and manganese

(Projected by Leontief)

	1990	2000	2010		2020		2030	
			Pessimistic	Optimistic	Pessimistic	Optimistic	Pessimistic	Optimistic
Copper * (10^6 tons)	17	24	27	31	35	43	44	58
Nickel (10^3 tons)	1,240	1,670	1,940	2,200	2,440	3,010	3,030	4,060
Manganese (10^3 tons)	23,100	36,500	38,300	44,500	47,700	60,600	59,200	81,700

Source: Leontief, et al., op. cit.

* Includes copper recovered from secondary sources (scrap).

43. The strengths of the input-output approach are in its explicit statement of economic conditions, which can be specified for alternative scenarios of future economic conditions to obtain a range of forecasts, and in its comprehensive view of world metal consumption. Its weaknesses are in the high level of effort required to develop and maintain the comprehensive world model, and the requirement that all economic and technical factors be specified for each year rather than determined internally in the model. For example, the magnitude and components of GDP must be specified for each forecast year. Also, technical change such as the substitution of aluminium for copper in automobile radiators would be accounted for by changing the element of the input-output matrix that specified the amount of aluminium and copper required to produce an automobile rather than allowing the ratios to be determined by the model itself based on the relative prices of the metals and other factors that might actually affect the substitution of one metal for the other.

Malenbaum: Intensity of use

44. In 1973, and again in 1977, Wilfred Malenbaum approached the forecasting of mineral and metal consumption from a perspective quite different from the detailed econometric and input-output models. 8/ He separated the forecasting process into two elements: a forecast of the growth of the economy, as measured by national gross domestic products (GDPs), and a forecast of the relationship between materials usage and level of economic development as indicated by the GDP. The ratio of materials consumption to GDP was designated the "intensity of use".

45. Malenbaum's approach was based on the concept that intensity of use varies in a non-linear fashion with regard to the level of economic development, beginning at a low level of intensity for the least developed countries, rising rapidly as the countries develop and then gradually decreasing as the economies reach a mature stage so that the intensity-of-use curve has an inverted U-shape. Malenbaum's forecasting methodology was particularly useful in projecting materials consumption in countries and regions where there were insufficient data to develop reliable econometric or input-output models. It also incorporated the concept of technological change in the qualitative determination of the shape of the intensity-of-use curve, which gave it an advantage over the generally static representation of technology in previous quantitative models.

Ridker: Combined intensity of use and input-output modelling

46. Intensity of use, as applied in the Malenbaum studies, offered insights that had not been available from other approaches to consumption forecasting. In research by R. G. Ridker and W. D. Watson, the strengths of input-output modelling for the domestic economy were combined with the benefits of the intensity-of-use approach in other economies where data were much less available. 9/ This modelling system utilized a complex input-output model of the United States economy, with input scenarios determined by a set of special-purpose models that relate the state of the economy to the output of products and certain environmental-effect indicators. Forecast of materials consumption for the United States were supplemented by forecasts for the rest of the world obtained through regional GDP projections and assumptions regarding the relationship of materials consumption with GDP (i.e. intensity-of-use relationships).

47. More recently, research has been reported about the integration of intensity of use directly into the structure of econometric and input-output models. 10/ Further development along this line holds the promise of marrying the strengths of historically derived projections of consumption and structural relationships with the trend towards reduced intensity of use resulting from improved materials processing, product design and fabrication, and introduction of substitute materials.

Other projections: banking organizations

48. While academic and government research organizations have pioneered many of the developments in metal consumption forecasting, banks and private firms also have an interest in the forecasting of markets for metal commodities. Banks in particular have extensive involvement in the minerals industry, so they have a strong interest in projecting the trends in the markets for the metals to be products from projects that they finance. Forecast of metal consumption by banks and private firms are generally developed to assist in making decisions related to investment and finance of mines and metal-processing facilities. The models and results of private banks and firms are generally proprietary and thus not subject to peer review or public scrutiny. This in no way suggests that the models are less useful.

49. World Bank. The World Bank makes projections of future demand and price of metals, essentially for the use of its loan officers responsible for administering loans to countries, in project appraisal. Out of the four minerals in which the Special Commission is interested, the World Bank carries out projections for copper and nickel. The projections extend up to the year 2000, and the projection exercise is carried out, and the results reported, every two years. 11/ In connection with the projection exercise, the mineral situation is under study continuously; there are, thus, half-yearly, quarterly, and monthly reports on the mineral situation. Econometric models incorporating supply-demand price equations are used for the purpose of projection. The results of the econometric modelling exercise are reviewed and modified, if necessary, by market analysts through the so-called Delphi method which involves incorporating opinions of experts in the field.

50. Chemical Bank. Projections of future growth of metals consumptions were made by Chemical Bank, as reported in a professional journal. 12/

Variability in projections

51. Seven recent forecasts of consumption of metals that can be produced from polymetallic nodules indicate the variability inherent in the forecasting of consumption. The long-term rate of growth for copper, cobalt, nickel and manganese for the seven forecasts is shown in table 3. There is considerable variation among the forecasts, part of which is due to the assumptions used and part is due to the structure and techniques embodied in the models. Interestingly, no single forecast produces the highest or lowest forecasts for all metals. The USBM and Leontief's forecasts are generally, though not always, the highest, and Chemical Bank and Ridker generally forecast the lower growth rates. Note that the 1985 USBM projection is more conservative than its predecessor for copper, nickel and manganese, due to the longer duration of the low growth period and increased concern of the metal analysts with regard to changes in intensity of use of the metals in the industrial economies.

Table 3

Comparison of long-term consumption growth rate forecasts

(per cent)

	USBM 1980	USBM 1985	Fischman	Leontief	Malenbaum	Ridker	Chemical Bank
Copper	3.9	2.7	3.1	4.4	2.9	2.7	2.1
Nickel	4.3	3.0	n/a	2.7	3.0	3.2	2.2
Cobalt	2.3	3.7	2.3	n/a	3.6	n/a	n/a
Manganese	2.7	1.4	2.6	4.9	3.4	0.6	1.4

Sources: See notes 4/, 6/, 7/, 8/, 9/ and 12/.

52. The variation of results of the seven forecasts of metals consumption exemplify the problems discussed earlier. In general, the factors can be divided into two groups: assumptions related to the economic climate and structural relationships between economic assumptions and the use of metals. In some models these factors are explicitly separated while in others they are intertwined.

53. As described above, there are a variety of tools that may be used to assess the outlook for future consumption of metals that can be obtained from seabed mining. Simple projections of past trends have been shown to be inadequate to the task of forecasting market behaviour in a dynamic world economy, but more sophisticated techniques have been developed to address this task. Econometric modelling was used to obtain more sophisticated forecasts by linking the behaviour of the metal markets to other factors of the economy. Input-output modelling also provided a tool to assess mineral and metal consumption under alternative economic scenarios. The introduction of the intensity-of-use hypothesis responded to the increasing importance of changing technologies and processes and their implication for the relationship between economic growth and future materials needs. Eventually, the insights of intensity-of-use analysis were incorporated into both econometric and input-output models, improving the capability of both to reflect more accurately the importance of technological change in materials consumption.

54. From the perspective of global metal projections, the type of model used matters less than the quality of data and professional judgement applied to the analysis. The best forecasts could result from the utilization of different models, each in their respective areas of strength, combined together to produce a global projection.

55. It must be recognized that the driving force for all of the demand projection models is the forecasting of the future growth of the world economy. The economy has thus far proven too complicated for definitive forecasting, so attempts to project future metals consumption must consider a range of potential economic futures.

56. As to future supply of copper, nickel, cobalt and manganese, in the view of the analysts who regularly monitor mine expansion and development activities, supply of the metals in the near future will be able to meet demand. If anything, there is the possibility that demand in the near future will fall short of supply capacity. With respect to the medium-term future, a comparison of land-based reserves, on the one hand, and cumulative demand to the year 2000 (based on demand projections), on the other, indicate that world reserves are sufficient to meet the world demand for copper, nickel, cobalt and manganese.

III. SOURCES OF DATA AND INFORMATION ON PROJECTION OF METAL SUPPLY/DEMAND/PRICE

57. Since it appears that the most fruitful approach would be for the Authority, when it commences functioning, to monitor the metal situation and to keep abreast of trends and developments in the metal markets, contacts and exchanges of information and ideas would be extremely useful with organizations, agencies and institutions interested or involved in projection exercises. For this purpose, a number of important sources of data and information on projection of metal supply/demand/price are described below. It is not feasible to list or identify all organizations, institutions or agencies that are involved in projection or related activities; however, the following is an indicative and illustrative list.

A. International organizations

World Bank

58. The development activities supported by the World Bank often address the exploitation of natural resources. Decisions to support particular projects are based on analytic assessments, and so the World Bank supports research into the behaviour of minerals markets and the development and use of forecasting models, as described earlier. At present, the World Bank is the most active international organization in the forecasting of markets for metals. The projections of metal consumption are published in the Bank's forecasts of commodity prices and consumption as well as in individual reports on particular commodities. According to the latest biennial publication of the World Bank on world mineral projection, world demand for refined copper is projected to increase at 1.8 per cent per annum over the 1989-2005 period, and world demand for nickel is expected to grow at an average rate of 1.7 per cent per annum during the 1990-2005 period.

Organisation for Economic Cooperation and Development

59. During the period of the 1970s and 1980s when negotiations were underway to consider mechanisms to manage commodity markets, the Organisation for Economic Cooperation and Development (OECD) convened groups of experts to study the markets for many commodities, including minerals. Several Governments supported the development and use of forecasting models to evaluate metal markets and the potential efforts of commodity agreements. With the decline in attention on commodity agreements, the support for these research activities has declined sharply.

Other international organizations

60. Organizations/departments/bodies within the United Nations, especially the United Nations Conference on Trade and Development (UNCTAD), regional commissions, the Department of Economic and Social Development, and the Committee on Natural Resources are interested in the future mineral situation, and can be important sources of data and information in relation to projected supply/demand/price of metals.

International commodity bodies

61. The International Nickel Study Group, and the International Copper Study Group are expected to be good sources of information on the projections with regard to the respective metals.

International commodity institutions

62. The International Manganese Institute, Paris, and the Cobalt Development Institute, Brussels, are interested in the future market situations with regard to the respective metals.

B. Government agencies

63. Governmental agencies and offices involved with international trade or the development and management of natural resources often require statistical information and forecasts of metal supply/demand/price to support the formulation of governmental policy. Such information can be obtained from a variety of public and private sources, but larger Governments may incorporate such analytical tasks within their own agencies. As an illustrative example, Energy Mines and Resources of Canada conducts studies, and forecasts markets for copper, nickel and ferrous metals over various time horizons.

64. Another example is the Bureau of Mines of the United States Department of the Interior, which compiles statistics and analyses trends in the production, consumption and trade of non-fuel minerals, as described earlier. While the focus of the USBM's work has shifted away from long-term projections, its metals analysts prepare forecasts as needed by the United States Government. It is currently evaluating its forecasting methodology, and will consider reinstituting its publication of forecasts when it completes its evaluation.

C. Private institutions/firms

65. The following is an incomplete, but illustrative, list of private institutions/firms that have prepared forecasts of markets and prices of metals contained in polymetallic nodules.

Brook Hunt & Associates, 19 Lincoln's Inn Fields, London WC2A 3EU, United Kingdom. It conducts studies and prepares forecasts for copper and nickel with time horizons of approximately 10 years. Reports are generally produced for clients and are proprietary in nature.

Charles River Associates, 200 Clarendon Street, Boston, Massachusetts 02106, United States of America. Charles River Associates (CRA) has been active in the development of models for metal markets for over 20 years. Their approach was largely in the development of large econometric models that were adjusted for special circumstances (anticipated changes, such as increased environmental costs). The models incorporate extensive information and judgement related to resources and reserves and production costs. Models of many metal markets, including copper, nickel and cobalt, were produced for the United States Government and were described in detail in reports, books and other publications. Currently, CRA maintains capability to forecast demand for copper, nickel, cobalt and manganese.

Commodities Research Unit, Ltd., 26 Red Lion Square, London WC1R 4RL. CRU conducts studies of copper and nickel markets with short-term (18-month) and longer-term (10-15 years) forecasts. Projections are proprietary.

Gill and Duffus, 201 Borough High Street, London SE1. It conducts studies of the market for copper, with time horizons of one month to five years.

Lehman Brothers International, One Broadgate, London EC2M 7HA. It recently produced Shearson Lehman's annual review of the world's nickel industry, 1991, predicting long-term growth of 4 per cent per year. Report findings are available at considerable cost.

Metals and Minerals Research Service, 222 Strand, London WC2R 1BA. It conducts studies of the markets for copper and nickel, with horizons extending to 10 years. Reviews of forecasts may be obtained in Metal Bulletin.

Resource Strategies Inc., 626 W. Lincoln Highway, Exton, Pennsylvania 19341, United States of America. It conducts studies of a number of metal commodities. They have the capability to forecast consumption of copper, nickel and manganese for a period of approximately 20 years.

66. In addition, some of the major metal producing and consuming industries often carry out projection exercises. For example, the Mining Journal in a recent issue reports: "Longer term, the rate of growth of nickel consumption will be linked to the level of industrial production, and INCO believes that an annual rate of 2-3% may well prove conservative". 13/

IV. *CONCLUDING REMARKS*

67. The above discussion highlights the usefulness of keeping abreast, in the near future, of available projections of demand/supply/price of copper, nickel, cobalt and manganese, and considering seriously the outcomes of the projected exercises at the time seabed mining appears imminent.

68. The factors behind the variability and the bias of projected outcomes become more intractable the longer the period is for which the projection is made. Thus, after the deliberations on the presentation made by an expert from the World Bank on the projection for copper and nickel markets, some of the points made in Special Commission 1 were: "(a) the degree of confidence in long-term projections is much lower than in short- and medium-term projections; (b) the mineral situation needs to be under constant study so that unforeseen developments, if any, can be spotted and their implications for long-term projections examined; (c) unforeseen developments, if sustained for a period of time, can have significant effects on long-term projections ..." (LOS/PCN/L.63, para. 7).

69. The issue of monitoring the mineral situation becomes all the more important in comparison with the study of current projections for the future 20 years from now, in view of the fact that: (a) many of the factors behind the variability of projections become more manageable in the perspectives of a foreseeable time period; (b) most of the uncertainties would play themselves out in the future and point to relatively clearer courses; and (c) the prevailing moods of the times are less likely to lead to contradictory decisions or actions.

70. These considerations moulded the approach taken by Special Commission 1, which is reflected in the provisional conclusion related to the issue of projection, of the deliberations in the Special Commission which can form the basis of its recommendations to the International Seabed Authority (revised suggestion by its Chairman). The provisional conclusion reads:

"Provisional conclusion 2

"Forecast of mineral situation with or without seabed production

"The Authority should collect available data and information on future seabed mining activities in the Area as well as existing forecasts on mineral situation. The Authority should consider and comment upon those forecasts when it has authorized the first plan of work for exploitation. If necessary, the Authority could carry out its own forecasting, based on the available data, information, and the existing forecasts on the mineral situation with and without seabed production, in accordance with the provisions of the chapeau, which would include, inter alia, supply-demand-price of the four metals concerned." 14/

Notes

1/ Official Records of the Third United Nations Conference on the Law of the Sea, vol. X (United Nations publication, Sales No. E.79.V.4), document A/CONF.62/RCNG/1, annex B (NG1/7), p. 28.

2/ David A. Gulley, "The new future of world metals: a conference report", Natural Resources Forum, vol. 11, No. 1, 1987, p. 70.

3/ Ibid., p. 71.

4/ United States Bureau of Mines (USBM), Mineral Facts and Problems, and Mineral Commodity Profiles, Washington, D.C., various issues.

5/ H. H. Landsberg, Leonard Fischman and F. M. Fisher, Resources in America's Future (Washington, D.C., Resources for the Future, 1963).

6/ Leonard Fischman, World Mineral Trends and U.S. Supply Problems (Washington, D.C., Resources for the Future, 1980).

7/ Wassily Leontief, James C. M. Koo, Sylvia Nasar and Ira Sohn, The Future of Non-Fuel Minerals in the US and World Economy: 1980-2030 (Lexington, Mass., Lexington Books, 1983).

8/ Wilfred Malenbaum, World Demand for Raw Materials in 1985 and 2000, National Science Foundation, Washington, D.C. (NS/RA-770421), 1977.

9/ R. G. Ridker and W. D. Watson, To Choose a Future (Baltimore, Md., Johns Hopkins Press, 1980).

10/ See Saul B. Suslick and DeVarle P. Harris, "Long-range metal consumption forecasts using innovative methods: the case of aluminium in Brazil to the year 2000", Resources Policy, September 1990; and Raymondo M. Valdes, "Modelling Australian steel consumption", Resources Policy, September 1990.

11/ World Bank, Price Prospects for Major Commodities, vol. 1, Washington, D.C., December 1990.

12/ Gerald Polio, "The outlook for major metals through the year 2000: an updated view", Journal of Resource Management and Technology, vol. 12, No. 2.

13/ "Thoughts on nickel", Mining Journal, 15 March 1991, p. 203.

14/ Informal document circulated among the members of the Chairman's Negotiating Group of Special Commission 1 at the end of the tenth session, containing "Provisional conclusions of the deliberations of Special Commission 1 which can form the basis of its recommendations to the International Seabed Authority (Revised suggestions by the Chairman)".